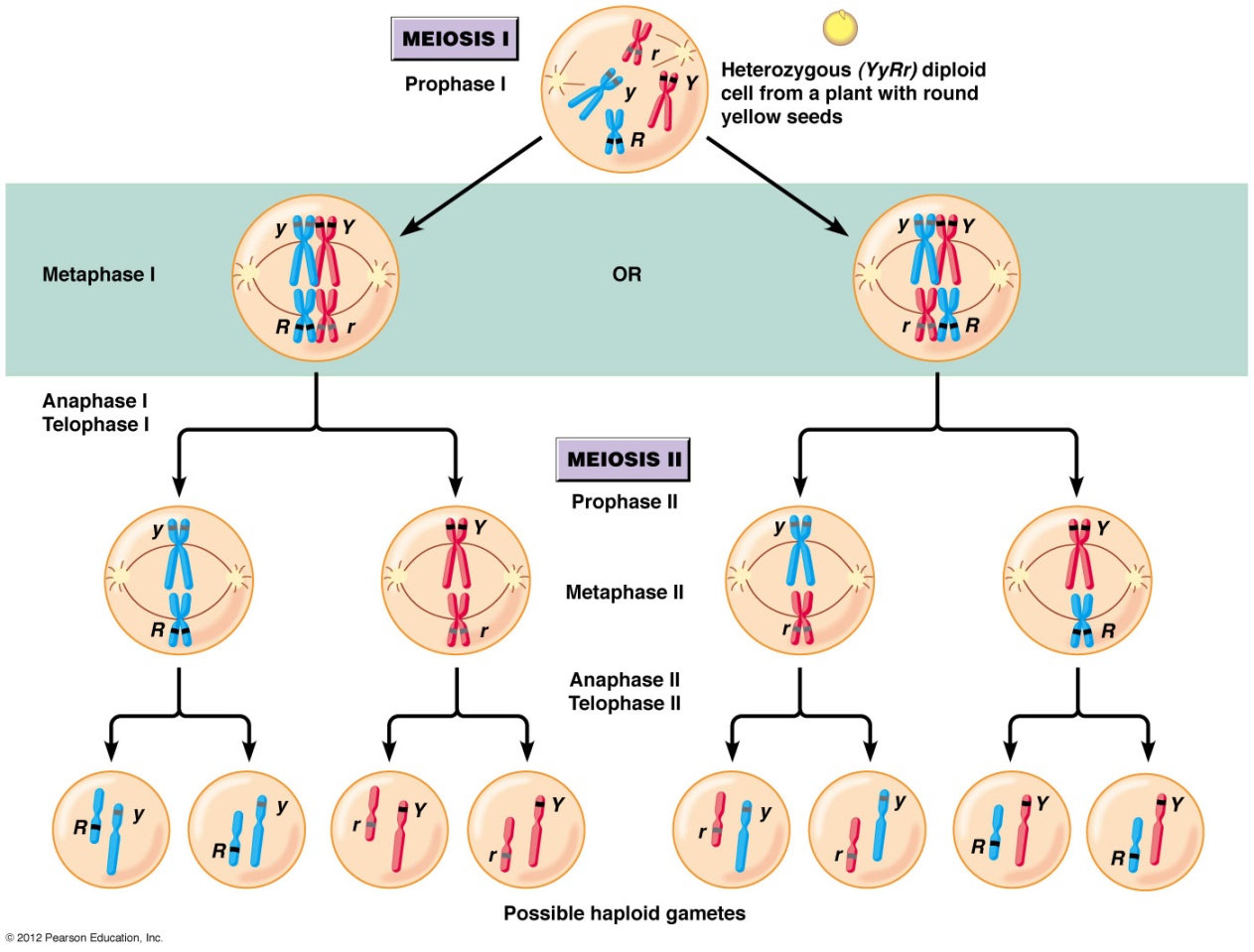
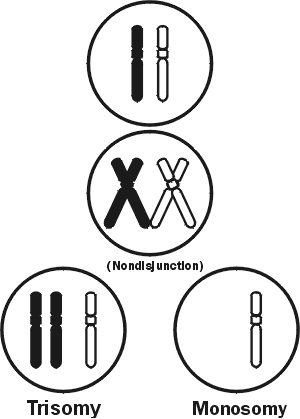
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**Unit 10 Notes, Part 3: Chromosomal Genetics**

Ms. Ottolini, AP Biology

1. **What are Mendel’s Laws of Inheritance?**
2. Gregor Mendel devised three laws of inheritance: The Law of Dominance, The Law of Segregation, and The Law of Independent Assortment.
3. The Law of Dominance states that a dominant allele completely masks the effects of a recessive allele. Therefore, when an individual has a heterozygous genotype (one dominant and one recessive allele), he/she shows the dominant phenotype only.
4. The Law of Segregation states that pairs of homologous chromosomes (and their alleles) are separated into gametes (eggs and sperm) during meiosis. Therefore, gametes only contain one allele for each gene. Below is an image showing meiosis and the inheritance of two genes, one for seed color (Y = yellow, y = green) and one for seed texture (R = round, r = wrinkled). Note that each of the gametes ends up with one copy of the seed color gene and one copy of the seed texture gene.
5. The Law of Independent Assortment states that genes on different pairs of homologous chromosomes separate independently into gametes. If genes are on different pairs of homologous chromosomes, the separation of one gene into a gamete is independent of the separation of the other gene into a gamete. This is because each pair of homologous chromosomes lines up independently of the others along the metaphase plate during Metaphase I of meiosis. The image below shows an individual with the following genotype RrYy. When determining the gametes that go on the top or side of a dihybrid Punnett square for this individual, we would use the FOIL method (see Unit 8 Notes, Part 1), giving us four possible gametes—RY, Ry, rY, and ry. The variety of possible gametes is a result of independent assortment. The pathway on the left in the image below shows one possible way the homologous chromosomes can line up, producing the gametes Ry and rY. The pathway on the right in the image below shows another possible way the homologous chromosomes can line up, producing the gametes ry and RY.

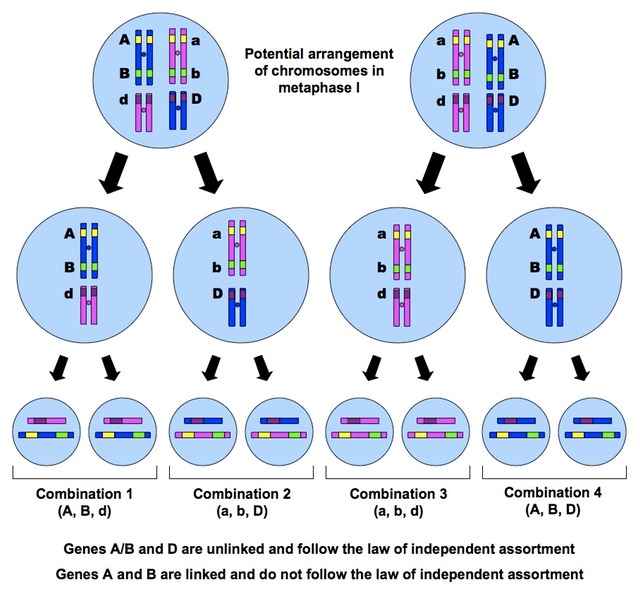


1. **What happens when alleles don’t segregate (separate) properly during meiosis?**
2. When chromosomes do not separate properly during meiosis, this is called nondisjunction. When this happens, gametes end up with an incorrect number of chromosomes, a condition called aneuploidy.
3. When a gamete ends up with both homologous chromosomes from a particular chromosome pair and this gamete is fertilized, the baby will have three copies of a particular homologous chromosome (one extra chromosome overall). This is called trisomy.

* When this happens to the 21st chromosome pair, the condition is called trisomy 21 (also known as Down Syndrome).
* When this happens to the sex chromosomes (the 23rd chromosome pair), an individual can end up having two X chromosomes and one Y chromosome (XXY). This condition is known as Klinefelter Syndrome.

1. When a gamete ends up with neither homologous chromosome from a particular chromosome pair and this gamete is fertilized, the baby will have only one copy of a particular homologous chromosome (one less chromosome overall). This is called monosomy.

* When this happens to the sex chromosomes (the 23rd chromosome pair), an individual can end up having only one X chromosome (XO). This condition is known as Turner Syndrome.

1. If nondisjunction occurs in ALL pairs of homologous chromosomes, this can result in a gamete with a full extra set of chromosomes. When this gamete is fertilized, it could result in a triploid baby (one with three sets of chromosomes instead of a normal baby that has two sets of chromosomes—i.e. a diploid organism).
2. Some species of plants end up with four sets of chromosomes (tetraploid) or more. When an organism as any number of extra sets of chromosomes, this is called polyploidy. For example, wheat plants have been hybridized and manipulated by humans, to the point where there are several strains—one that is diploid, one that is tetraploid, and one that is hexaploid. Polyploidy often results in speciation, the creation of species with different “ploidy’s” that can no longer mate. For some reason, polyploidy can result in species of plants that are more vigorous / healthy than the normal diploid species. Polyploidy has also been documented in fish and amphibians.
3. **How are genes inherited when they are located on the same chromosome?**
4. Genes that are located on the same chromosome do not follow the Law of Independent Assortment. Instead, they are always inherited together, unless they are separated by crossing over between homologous chromosomes. The image to the right, shows two genes (A and B) that are found on the same chromosome. These are called linked genes. Gene D is found on another chromosome, so it is considered “unlinked” to genes A and B.
5. Because they are found on the same homologous chromosome, alleles A and B always separate into gametes together. Because they are found on the same homologous chromosome, alleles a and B always separate into gametes together. For this individual with the genotype AaBb, this results in only two possible gamete combinations for these two genes—AB and ab. If the genes were unlinked, there would be four possible gamete combinations—AB, Ab, aB, and ab.
6. For this individual, there is a chance that the gametes Ab and aB can be produced if crossing over occurs between the pair of homologous chromosomes. Let’s say gene A controls height and that A = tall and a = short. Let’s say gene B controls eye color and that B = brown and b = blue. If two individuals with the genotype AaBb were crossed and the genes A and B were unlinked, the following phenotype ratio would result in the offspring.

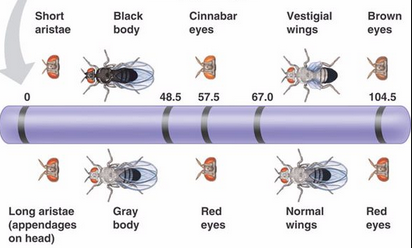
|  |  |
| --- | --- |
| **Phenotype** | **Number of Offspring** |
| Tall, Brown | 9 |
| Tall, Blue | 3 |
| Short, Brown | 3 |
| Short, Blue | 1 |

If two individuals with the genotype AaBb were crossed and the genes A and B are linked (as in the image on the previous page), the following phenotype ratio could result in the offspring.

|  |  |
| --- | --- |
| **Phenotype** | **Number of Offspring** |
| Tall, Brown | 7 |
| Tall, Blue | 1 |
| Short, Brown | 1 |
| Short, Blue | 7 |

The individuals that are tall / blue and short / brown resulting from separation of the linked genes by crossing over between homologous chromosomes.

1. The first linked genes were discovered by Thomas Hunt Morgan in fruit flies.
2. **How often are linked genes separated by crossing over?**
3. Genes that are located farther apart from one another on the same chromosome are more likely to be separated by crossing over.
4. Scientists can determine the frequency of genes being separated by crossing over by studying offspring phenotype ratios. The frequency of genes being separated by crossing over is known as the recombination frequency for those particular genes.
5. Recombination frequencies can be used to construct linkage maps showing the locations of gene loci (gene locations) along the length of a chromosome. The distance between two genes on a chromosome is measured in map units. 1 map unit corresponds to 1% recombination frequency. In other words, the genes are only separated by crossing over 1% of the time during meiosis.
6. Below is a linkage map of several genes located on a fruit fly chromosome.



1. Recombination frequencies below 50% correspond to genes located on the same chromosome, and recombination frequencies above 50% correspond to genes located on different chromosomes or genes that are so far apart on the same chromosome that their offspring phenotype ratios suggest they are unlinked.